National Library of Medicine Trans-Pacific Digital Library Experiment Description

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Michael Gill
Communications Engineering Branch[1]
Lister Hill National Center for Biomedical Communications
National Library of Medicine

National Library of Medicine (NLM) Background[2]: The NLM, part of the National Institutes of Health[3] is the world's largest biomedical library. It has in its collection over five million items--books, journals, technical reports, manuscripts, microfilms, photographs and images. It is the producer and distributor of MEDLINE and 40 other biomedical databases including GENBANK and other biotechnology information sources used by biomedical scientists and clinicians worldwide. Divisions include library operations, R&D centers, and international centers for database distribution.

Visible Human Project[4]: This project originated in recommendations by a long-range planning panel of the NLM. It was foreseen that image database services provided over high-speed computer networks would complement its bibliographic and factual database services. So a project was formed to build a digital image library of volumetric data representing a complete, normal adult male and female cadaver. The data collection phase has been completed for this initial effort and the data resides at the NLM. Images include those of digitized photographic images of cryosections, digital images derived from computerized tomography, and digital magnetic resonance images of the two cadavers.

A second phase has begun which includes the segmentation, classification, and three-dimensional rendering of the data set. A new research effort is under way. Its ultimate objective is to identify all anatomical structures within the Visible Human dataset including the extent of each structure. This effort is nearing completion for the male thorax. Each object in each cross-section will be labeled. The relationship of each object to the other objects in its cross-section and in the adjacent cross-sections will be cataloged. The extent of a single object which spans several cross-sections will be noted. In order to accomplish this, information about building geographic databases and databases associated with computer-aided drafting systems will be used as starting points for developing this unique interactive anatomical digital atlas.

The Visible Human (VH) Project data sets are designed to serve as a common reference point for the study of human anatomy, as a set of common public domain data for testing medical imaging algorithms, and as a test bed and model for the construction of image libraries that can be accessed through networks. The data sets are being applied to a wide range of educational, diagnostic, treatment planning, virtual reality, artistic, mathematical and industrial uses by over 1,000 licensees in 41 countries. But key issues remain in the development of methods to link such image data to text-based data. Standards do not currently exist for such linkages. Basic research is needed in the description and representation of image based structures, and to connect image-based structural-anatomical data to text-based functional-physiological data. The larger, long-term goal of the Visible Human Project is to transparently link the print library of functional-physiological knowledge with the image library of structural-anatomical knowledge to create one unified resource for such health information.

At present, Visible Human image data amounts to about 15 GB for the male cadaver and 40 GB for the female cadaver. The male dataset consists of axial MRI images of head and neck and longitudinal of rest of body at 4 mm intervals at 256x256x12 bits. Axial

CT scans of the entire body at 1-mm intervals at 512x512x12 bits per scan. Anatomical cryosectioning via CCD scanning with axial images at *1 mm* intervals at 2048x1216x24 bits color (bulk of dataset). 1871 cross-sections for each mode. The female dataset is the same except the anatomical cryosection images are at *.33 mm* intervals resulting in 5000 cross-sections. When the high resolution scanning of the 70 mm color photographs taken of each slice is completed, we expect the total image data to be five times the current amount.

Motivation: The proposed experiment will attempt to prove a model which enables interactive biomedical image segmentation, labeling, classification, and indexing to take place using large images. The VH dataset is an information rich dataset not existing in private sector datasets because commercial subsets of the VH dataset are often compressed by lossy techniques and hence information reduced. By maintaining a centralized repository, management of the resulting database will be more easily done. Updates would be in one place, ensuring authenticity and reliability. Biomedical image libraries (in number and size) are sure to grow. Currently licensees of the VH dataset number 1000+ worldwide. Due to the size and international importance of the dataset, multilingual labeling of the dataset has been proposed. Therefore various researchers are needed to provide image segmentation and labeling. The first such researcher in Japan will work on a lower extremity subset of the Visible Human dataset. Other potential off-site collaborators exist in Europe. In the future online access to an anatomical segmented human anatomy atlas will be a vital resource for biomedical researchers worldwide. One model involves having NLM developed client software with browser access to the VH dataset selecting a cropped volumetric subset (e.g. the heart). The client software would receive the volume of interest and all labels. A client will do the rendering with a (future) generic rendering tool possibly being supplied. This work has been proposed as part of other efforts to enhance interoperability of global broadband networks[5].

Experiment: The first element involves proof of concept of a prototype system for *interactive biomedical image segmentation, labeling, classification, and indexing*. Its primary focus is a Biomedical Image Collaboratory between Dr. Haruyuki Tatsumi of Sapporo Medical University (SMU) and NLM. A second element is a remote telemicroscopy experiment between Dr. Paul Fontelo of NLM, and Drs. Katsushige Yamashiro and Tatsumi of SMU. This involves as well remote operation of a videodisc via ATM. A third element is remote backup of a large dataset. The fourth-seventh elements are to conduct NLM related experiments with the experimental high-speed link including evaluation of the WebMIRS system involving browser access to multimedia database of digitized x-ray images and text data from nationwide surveys; demonstration of an online radiological atlas; link performance analysis; and remote viewing of NIH seminars via digital video transmission. Details of the experiments follow.

Interactive Visible Human image indexing: This relies on a Visible Human Viewer program developed on OpenStep (an Apple Applications Programming Interface). This application can show sagital and longitudinal, coronal sections of a human body, and enables a researcher to make an interactive segmentation in order to recognize each anatomical object. Also, it calculates and fills areas in the segment with metaballs, and

renders them. This would be followed by the attachment of anatomical terms to the objects working with NLM's Unified Medical Language System (UMLS[6]) and creating a multilingual object database. Visible Human data would be transferred to and from the researcher via FTP or via NFS (Network File System) with other methods to be determined[7].

Remote Microscopy: Telepathology is a component of telemedicine that requires a consultant pathologist to control a robotic microscope remotely. Because of quality of service issues (high latency, jitter), it is necessary for remote microscopy to be evaluated carefully. Quality-of-service requirements are also of significance in other "tele"-based medical procedures. This experiment can address these requirements for "across-the-table" capability to robotically-controlled microscopes. Collaborators in Sapporo Medical University operate an IP-based robotic microscope. Our experiment will allow a pathologist at the NLM (Dr. Paul Fontelo) to control the robotic microscope in Sapporo, Japan. This includes moving the microscope stage, focusing on a glass slide from a clinical specimen, and receiving streaming video from the microscope camera as the slide is moved and focused. Images will be captured and archived and a videoconference link will be maintained between Sapporo Japan and Bethesda Maryland[8].

A preliminary experiment of "Remote Microscopy' will be carried out called "Remote Control over ATM". It is important to compare IP-based streaming video with direct NTSC video over ATM cells in terms of responsiveness on global data transmission. Responsiveness is a critical part of the 'Remote Microscopy' experiment in order to consider it as a useful application in medicine. This preliminary experiment will be an application that handles a remote Laser VideoDisk player. Control sequences of the player will be transported via TCP/IP, but video images will be via direct ATM cells.

TransPacific Backup: SMU has a high-speed backup equipment (Sony GY-2120) that can store 42GB(uncompressed)/108GB(compressed) per tape cartridge. This test will verify the reliability and ease of making a tape backup of the whole Visible Human data.

WebMIRS evaluation: The Web-based Medical Information Retrieval System developed at NLM provides access to two databases of U.S. health survey information of national importance, plus the digitized x-ray images of the cervical spine and lumbar spine collected in one of the surveys. The use of the system will be evaluated by having the user in Japan carry out queries of the data to retrieve both text and image data. The queries used will be substantive and important, and will be based on published biomedical research using this health survey data. End-to-end data retrieval time data will be collected.

Online Radiological Atlas: The online radiological atlas developed at NLM serves as a reference source for evaluating images of the cervical and lumbar spine for the degree of presence of several conditions related to osteoarthritis and degenerative disc disease. The value and reference role of the system will be evaluated by having the user in Japan access images from the atlas for display. End-to-end data retrieval time will be collected.

Link performance analysis: Testing protocols will include bulk file transfer testing (ftp), round-trip delay (ping), one-way delay and packet loss through placement of a Surveyor (www.advanced.org) node at NLM and SMU. NLM has acquired a Surveyor system as well and performance data will be gathered and summarized between the two nodes.

NIH seminars: Digital video and audio of NIH-located scientific conferences will be sent to medical institutions in Japan for evaluation of quality and viewing convenience aspects of remote conference participation.

Payoffs

Interactive Visible Human image indexing: The value of high speed networks will be proven, not by the exchange of small files such as email, but by highly interactive activities involving databases of data-intensive large image files such as digitized color cryosection images and biomedical x-rays. The proposed experiment relies on interactive tools, large image files, databases, and high speed networks for its successful completion.

This would be a multi-lingual anatomical labeling effort to prove the wide applicability of the NLM's UMLS, and make multi-lingual access to the future Visible Human database possible. This will enable anatomical labels to be displayed in various languages. One could imagine a "white board" program which enables images to be displayed simultaneously at sites in different countries but with the labels in the appropriate language. This can serve as a test bed and model for other medical applications where interactive and simultaneous multilingual labeling of images is appropriate. Opportunities exist in the areas of professional medical education or patient education and information. Automated multi-language labeling would be a useful aid during international telemedicine consultation sessions[6].

Remote microscopy: If the experiment is successful, this could provide significant insight on the prospects of telesurgery and other robotically-controlled medical procedures.
The preliminary Remote Control over ATM experiment would demonstrate performance of both IP-based streaming video and NTSC over ATM, and would bring a quantitative and qualitative estimation for better video transfer so that 'Remote Microscopy' would be more applicable to medical practice. It would prove the effectiveness of employing both control and content signals in an ATM channel.

TransPacific Backup: Enhancement of the medical image database/image archive update process.

WebMIRS evaluation: This experiment will establish the viability of WebMIRS as a Web tool accessible and usable internationally.

Online Radiological Atlas: This experiment it likewise will establish the viability of the atlas as a tool internationally accessible through the Web in a practical manner.

Link performance analysis: Add to the body of knowledge about performance over long multi-satellite hops.

NIH seminars: Enhanced access to biomedical research data via wider distribution of information.

Research Team Members

-The Japanese principle investigators are Haruyuki Tatsumi, MD, PhD, tatsumi@sapmed.ac.jp, and Hiroki Nogawa, MD, PhD, nagawa@sapmed.ac.jp both researchers at Sapporo Medical University in Sapporo Japan.

-NLM team members are members of the Lister Hill National Center for Biomedical Communications, a research and development arm of the NLM. They include Dr. George Thoma, thoma@nlm.nih.gov, Rodney Long long@nlm.nih.gov, Dr. Michael Ackerman ackerman@nlm.nih.gov, Dr. Paul Fontello, fontello@nlm.nih.gov, Michael Gill, mike_gill@nlm.nih.gov, and Leif Neve, neve@nlm.nih.gov. NLM team members are located on the NIH Campus in Bethesda Maryland.

-USA Collaborators/collaboration sites: Eddie Hsu, Jet Propulsion Laboratory, Christine Falsetti, NASA Ames Research Center, Patrick Gary, NASA Goddard Space Flight Center.

References

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[2]National Library of Medicine: http://www.nlm.nih.gov
[3]National Institutes of Health: http://www.nih.gov.
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http://www.nlm.nih.gov/pubs/factsheets/visible_human.html
[5]Global Information Broadband Network Digital Libraries Experiment:
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[6]Unified Medical Language System Fact Sheet:
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